LJ86-15

SOUTHWEST FISHERIES CENTER

NATIONAL MARINE FISHERIES SERVICE SOUTHWEST FISHERIES CENTER P.O. BOX 271 LA JOLLA, CA 92038

LIBRARY
JUL 17 1986
National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

MAY 1986

SEX DETERMINATION OF THE CALIFORNIA SEA LION *(Zalophus californianus)* FROM CANINE TEETH

By

Mark S. Lowry and Roberta L. Folk

ADMINISTRATIVE REPORT LJ-86-15

This Administrative Report is issued as an informal document to ensure prompt dissemination of preliminary results, interim reports and special studies. We recommend that it not be abstracted or cited.

Sex Determination of the California Sea Lion (*Zalophus californianus*) from Canine Teeth

Mark S. Lowry
National Marine Fisheries Service
Southwest Fisheries Center
P.O. Box 271
La Jolla, California 92038

Roberta L. Folk
3122 38th Street
San Diego, California 92105

May 1986

ADMINISTRATIVE REPORT LJ-86-15

TABLE OF CONTENTS

	Page
ABSTRACT	1
INTRODUCTION	1
METHODS	2
RESULTS	3
DISCUSSION	3
ACKNOWLEDGEMENTS	5
LITERATURE CITED	6

LIST OF TABLES

Table		Page
1	The ranges and means of measurements for 267 sampled canine teeth taken from known-sex California sea lions (*Zalophus californianus*).....	8
2	Two measurements and their canonical coefficients, the constant, and group mean chosen by BMDP7M stepwise discriminant analysis of California sea lion (*Zalophus californianus*) canine tooth measurements.....	9
3	Specimen number, sex, standard length, collection date, growth layer group (GLG) counts of canine dentine, and estimated age of California sea lions (*Zalophus californianus*) specimens whose canine teeth are pictured in Figure 2.....	10

LIST OF FIGURES

Figure		Page
1	Measurements taken of California sea lion (*Zalophus californianus*) canine teeth.....	11
2	Ontogenetic series of upper and lower canine teeth from known sex California sea lions (*Zalophus californianus*.....	12
3	Canine teeth from an approximately 7 month old female California sea lion (*Zalophus californianus*) showing exposed region (discoloration) at the apex of a fully developed crown.....	13

Sex Determination of the California Sea lion (*Zalophus californianus*) from Canine Teeth

Mark S. Lowry and Roberta L. Folk

ABSTRACT

Measurements of canines from California sea lion (*Zalophus californianus*) carcasses were used to demonstrate an alternate method for accurately determining the sex of animals which have missing genitalia or which are otherwise of unknown sex. A total of 267 canines was measured from 111 carcasses (68 males and 43 females). A multivariate ANOVA of five canine measurement vectors showed a positive difference in the size of canines between male and female for all canine locations. Stepwise discriminant analysis produced a discriminant score function which can be used for determining the sex of unknown-sexed California sea lions.

INTRODUCTION

Information from stranded or beached marine mammals has been used to determine sex ratios of samples of dead animals (Hansen, 1983A) and to complement studies on free-ranging animals (Hansen, 1983B). Knowledge of the sex of stranded animals is needed to interpret data on stomach contents, skeletal morphology, or other sex-related studies. Sex determination from genitalia may not be possible because the soft tissue of animals that have been stranded a long time is often decomposed.

While extracting canines from carcasses of California sea lions (*Zalophus californianus*) to obtain age information, we noted a size difference between male and female canines. A literature review indicated that other researchers have reported the use of canine measurements for determining sex. Fuller et al. (1984) used the canines to determine sex of striped skunks, *Mephitis mephitis*. Crespo (1984) working on southern sea lions, *Otaria flavescens*; Parson et.al. (1978), on fishers, *Martes pennanti*; and Sauer (1968), on black bears, *Ursus americanus*, all used measurements of canines to determine sex. Flook and Rimmer (1965) used skull and dental measurements to determine sex of wolverines, *Gulo gulo*. This is a report of our attempt to determine whether canine size is useful for determining the sex of California sea lions.

METHODS

A number of researchers (see acknowledgements) collected carcasses of California sea lions from (1) coastal mainland beaches of San Diego County, California; (2) San Clemente, Santa Catalina, and San Nicolas islands, California; (3) Bolsa Chica State Beach, Orange County, California; (4) Farallon Islands, California; and (5) vessels at sea where the animals were inadvertently taken during fishing operations. Carcasses varied in size and age from pups to adults. Canines were removed either while the carcasses were collected or later.

We measured maximum crown length, width, and thickness, and the maximum root width and thickness (Figure 1) of upper and lower canines. We made all measurements to the nearest 0.01 mm. We measured crown length in a straight line at the concave side of the canine (posteriorly) from the neck to apex. We measured crown width and thickness at the widest region of the neck or base of the crown. We measured root width and thickness at the root's widest and thickest region. We did not take all measurements of each individual canine due to one or more of the following reasons: (1) the crown was too worn; (2) the canine had been sectioned for age determination before all measurements were obtained; and (3) the root in the canines of some pups had not developed. We calculated range and mean crown length, width, and thickness, and root width and thickness for all specimens of known sex (Table 1).

We tested for sex-related difference in canine measurements for each of the four canine locations (e.g. upper right canine) separately. For each canine from a specific location, we defined a vector of five measurements (root width and thickness, and crown length, width, and thickness) and tested for sex-related differences using multivariate ANOVA (program BMDP4V). Only those canines having all five measurements were used in the test.

We also performed a discriminant analysis for each of the four canine locations (program BMDP7M). The program produced a score function that can be used to ascertain the sex of a sea lion based on the canine measurements from one of its four canines. The score function is:

$$S = C_1 X_1 + C_2 X_2 + k$$

where C_1 and C_2 are the canonical coefficients for the two measurements chosen by the program; X_1 and X_2 are the canine measurements from the unknown-sex sea lion corresponding to the coefficient measurement; k is the constant given by the output; and S is the discriminant score. The discriminant score (S) closest to the group mean of each sex determines the sex of the previously unknown-sexed animal.

A representative sample of canines from various age class sea lions was photographed to demonstrate that (1) crown measurements of canines do not differ once the crown of the

canine is formed, and (2) that there is a visual difference in the size of the canines between males and females. Ages were either known (animals had been tagged as pups at San Clemente and San Nicolas Islands) or estimated by acid-etching another canine from the same animal (Pierce and Kajimura, 1980). For animals lacking the neonatal line in the dentine of the canine, an approximate age was determined by taking the difference between the specimen collection date and the median birth date of the 1984 breeding season at San Nicolas Island, which took place between June 12 and June 18 (B. Stewart, per. commun.). Counts of growth layer groups (GLG's), as defined by Myrick (1980), were made of the dentine to estimate age of animals greater than one year old. GLG's were calibrated from a 12 year old captive male California sea lion. Each GLG was found to represent one year.

RESULTS

We measured 267 canines from 111 carcasses of known sex (68 males and 43 females). The spatial location of root measurements varied among canines due to individual differences in root development. Little variation in the shape of the crown was observed except for wear affecting the crown length in some specimen material.

Mean root and crown measurements were different between sexes for all canines (Table 1). The range of measurements showed no overlap for all measurements. For each of the four canine locations, we rejected the hypothesis of equal male and female mean canine measurement vectors ($P < 0.0001$, in each case). Therefore, the five canine measurements differ significantly by sex.

For each canine, the BMDP7M stepwise discriminant analysis chose (1) two out of the five canine measurements which can be used for determining the sex of unknown-sexed sea lions; (2) a canonical coefficient for each of the two measurements chosen; (3) a constant; and (5) group means for each sex (Table 2). No discrepancies were found by the BMDP7M program when it checked measurements of the known-sexed sea lions to determine if any of the measurements were from incorrectly sexed animals (i.e. it looked for measurements that were out of range).

The canines shown in Figure 2 are arranged from younger (pup) to older (adult). Standard length, sex, and estimated age of the animals whose canines are pictured in Figure 2 are provided in Table 3. This series shows that (1) the root increases in length with age while the crown remains constant in width and length and (2) there is a strong difference in the overall size of the canines between sexes for each age class.

DISCUSSION

Our results indicate that California sea lions can be sexed by examination of any of their canines. Statistical and visual evidence show that there is a significant difference between

canine size of males and females. Our procedures and formula provide a means to readily determine the sex of sea lions which have missing genitalia or which are otherwise of unknown sex.

Ideally, the formula we derived for determining sex of sea lions should be tested on a separate sample of canines collected from known-sex animals that were not used for deriving our formula. We were not able to do this test because all canines from known-sex sea lions in our collection were used to derive the formula. However, we are confident in our results because: (1) there was no overlap between male and female canine measurements (Table 1); (2) a multivariate ANOVA test showed that male and female canines measurements were statistically different ($P < 0.0001$); and (3) photographs of canines from various age-class sea lions (Figure 2) show visual evidence of sexual dimorphism in canines of California sea lions.

Previous workers have demonstrated that canine measurements can be used to determine sex for various animals. The best determinate for fishers (Parsons et al., 1978) and black bears (Sauer, 1968) was found to be the root width. Fuller et al. (1984) used a discriminant score function with measurements of the root (width, thickness, and length) for determining sex in striped skunks. Crespo (1984) used angle measurements of the crown for sex determination of the southern sea lion.

Two criteria are necessary for using measurements of California sea lion canines to determine sex: (1) the crown must be completely developed; and (2) the root must show signs of development. These criteria will differentiate animals which are too young for the sex determination measurements to be effective in distinguishing the sex of the animal. Permanent teeth begin to form within the alveolus of the upper and lower jaws while milk teeth are in wear. As in all mammals the crown is formed first; we observed this from canines we extracted from a male new-born and female new-born pup that died shortly after birth. Once the crown is fully developed, there is a basal bulge on the crown immediately adjacent to a slight indentation encompassing the tooth. The root develops after the crown is formed and increases in length as the animal grows older. A layered coat of cementum is deposited on the outside of the root during its development. Ultimately the crown is fully exposed and the root of the canine completely fills the alveolus as the sea lion completes its physical development as an adult. We estimate that these criteria are exhibited at approximately five to six months of age for males and as early as three to four months of age for females. The canine shown from the youngest sea lion male in Figure 2 (specimen A in the photograph) was collected from a 5 month old animal (specimen MSL0193 in Table 5). The lower canine from this young male specimen displays a crown that is almost fully developed and has signs of a developing root. A canine from the youngest female specimen (specimen I in Figure 2, specimen CBH0021 in Table 5) was collected from a freshly dead pup. The canine from this young female sea lion shows a well developed crown with a basal bulge followed by a slight

indentation in the root system, thus, indicating that it may be possible to determine sex from canines of females younger than three to four months of age.

The canines of pup and juvenile sea lions must be removed from the skull or mandible to determine relative size of the teeth because part of the crown remains embedded in the alveolus. The discolored region evident on the apex of the canines shown in Figure 3 denotes the exposed portion of the fully developed crown from these teeth taken from a pup. Therefore, the entire canine of pups and juveniles must be extracted from the bone to determine the sex of the specimen since the exposed crown of young males and females may look similar before they are fully erupted.

It is likely that the maximum diameter of either width or thickness of the alveolus can also be used for determination of sex in adults if the teeth are absent from the carcass.

Because California sea lions are sexually dimorphic in physical size (males reach 236 cm in length and weigh up to 281 kg, and females reach 183 cm in length and weigh up to 91 kg [Scheffer, 1958]) and because this dimorphism is also expressed in the size of the canines, we postulate that our technique may be of use in determining the sex of badly decomposed carcasses of other pinnipeds which are sexually dimorphic. Potential candidates are otariids such as the Guadalupe fur seal, Arctocephalus townsendi; northern fur seal, Callorhinus ursinus; and northern (Stellar) sea lion, Eumetopias jubatus; and, phocids such as the northern elephant seal, Mirounga angustirostris.

ACKNOWLEDGEMENTS

We wish to thank Larry Hansen, Chuck Oliver, Sandra Paez, Sandy Shay, John Henderson, Doug DeMaster, Lisa Ferm, Jeanne Wexler, Carolyn Heath, Dana Seagars, Harriet Huber, and any others we may have overlooked, for collecting the canines from California sea lion carcasses. This project was supported by the Marine Mammal Salvage Program at the Southwest Fisheries Center in La Jolla, California. We would like to thank Carolyn Heath for providing the specimen material and data for specimens CBH0021 and DJS0011 (tagged as a pup at San Nicolas Island with Red Reise #492); Chuck Oliver for providing the specimen material and data for specimen LJH0043 (tagged as a pup at San Clemente Island with White Roto #58); and Bill Walker for donating the skull from the 12 year old male California sea lion (specimen WAW0756) which was used to calibrate GLG's. We are thankful to Bruce Wahlen and Carolyn Mackey for their statistical assistance in this project. We also thank Henry Orr for photographing and drawing the teeth. Many useful comments which improved the manuscript were given by Douglas DeMaster, Albert Myrick, Chuck Oliver, and Wes Parks.

LITERATURE CITED

Crespo, E.A. 1984. Dimorfismo sexual en los dientes caninos y en los craneos del lobo marino del sur, Otaria flavescens (Shaw)(Pinnipedia, Otariidae). Revista del Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" e Instituto Nacional de Investigacion de las Ciencias Naturales, Zoologia, 9(25):245-254.

Flook, D.R. and J. Rimmer. 1965. Cannibalism in starving wolverines and sex identification from skulls. Can. Field-Nat. 79:171-173.

Fuller, T.K., D.P. Hobson, J.R. Gunson, D.B. Schowalter, and D. Heisey. 1984. Sexual dimorphism in mandibular canines of striped skunks. J. Wildl. Manage. 48(4):1444-1446.

Hansen, Larry J. 1983A. The Cooperative Marine Mammal Salvage Program: Report on Strandings of Dead Animals in 1981. SWFC Admin. Rep. No. LJ-83-03.

----- 1983B. Population Biology of the Coastal Bottlenose Dolphin Tursiops truncatus, of southern California. (THESIS) Calif. St. Univ., Sacramento.

Myrick, A.C. Jr. 1980. Report of the workshop: Section G, Glossary. In: Age Determination of Toothed Whales and Sirenians, W.F. Perrin and A.C. Myrick, eds. Reports of the International Whaling Commission: Special Issue 3.

Parson, Gary R. Mark K. Brown, and Gary B. Will, 1978. Determining the sex of fisher from the lower canine teeth. N.Y. Fish & Game J. 25(1):42-44.

Pierce, K.V. and H. Kajimura, 1980. Acid etching and highlighting for defining growth layers in cetacean teeth. In: Age Determination of Toothed Whales and Sirenians, W.F. Perrin and A.C. Myrick, eds. Reports of the International Whaling Commission: Special Issue 3.

Sauer, Peggy R. 1968. Determining sex of black bear from the size of the lower canine tooth. N.Y. Fish & Game J. 13(2): 140-145.

Scheffer, Victor B. 1958. Seals, sea lions, and walruses; a review of the pinnipedia. Stanford Univ. Press. 179p.

Table 1. The ranges and means of measurements for 267 sampled canine teeth taken from known-sex California sea lions (Zalophus californianus).

LOCATION OF CANINE	MEASUREMENT	FEMALES MEASUREMENTS (mm) N	MINIMUM	MAXIMUM	Mean	MALES MEASUREMENTS (mm) N	MINIMUM	MAXIMUM	Mean
Upper Right	Crown Length	25	12.44	16.39	14.33	29	19.36	24.74	21.74
	Crown Width	26	6.58	9.72	8.11	33	11.17	15.89	13.78
	Crown Thickness	26	4.07	7.26	6.08	32	9.09	11.95	10.09
	Root Width	29	8.17	12.40	10.09	35	14.32	20.79	17.26
	Root Thickness	29	5.64	10.42	8.25	35	10.43	16.19	13.17
Upper Left	Crown Length	24	12.89	16.44	14.36	31	19.24	24.20	21.80
	Crown Width	26	6.36	9.75	8.27	37	11.09	15.44	13.63
	Crown Thickness	25	5.46	7.66	6.38	35	8.15	11.29	9.94
	Root Width	29	8.42	12.29	10.43	38	13.78	22.85	17.31
	Root Thickness	29	6.72	10.29	8.49	38	10.41	15.05	13.08
Lower Right	Crown Length	26	10.97	14.96	13.25	41	21.05	27.26	23.98
	Crown Width	26	6.03	9.70	7.59	41	11.10	17.08	13.83
	Crown Thickness	26	3.84	6.18	5.18	41	7.24	10.47	8.70
	Root Width	25	7.45	11.40	9.14	39	14.19	22.28	17.31
	Root Thickness	25	4.50	7.52	5.90	39	8.20	18.30	10.41
Lower Left	Crown Length	28	11.51	14.45	13.41	40	17.76	26.13	23.56
	Crown Width	28	6.19	9.81	7.70	43	11.31	16.79	13.58
	Crown Thickness	28	4.04	5.96	5.17	43	7.00	10.45	8.62
	Root Width	27	7.77	11.20	9.16	40	12.35	21.98	17.10
	Root Thickness	27	5.04	7.37	5.96	39	8.06	12.34	10.28

Table 2. Two measurements and their canonical coefficients, the constant, and group mean chosen by BMDP7M stepwise discriminant analysis of California sea lion (Zalophus californianus) canine tooth measurements.

UPPER RIGHT CANINE:

Measurement #1: Root width; canonical coefficient = 0.45310

Measurement #2: Crown length; canonical coefficient = 0.65066

Constant = -18.15078

Group mean: male = 3.78232

female = -4.25510

UPPER LEFT CANINE:

Measurement #1: Root thickness; canonical coefficient = 0.56455

Measurement #2: Crown length; canonical coefficient = 0.68219

Constant = -18.80779

Group mean: male = 3.39794
female = -4.24743

LOWER RIGHT CANINE:

Measurement #1: Root width; canonical coefficient = 0.26639

Measurement #2: Crown length; canonical coefficient = 0.55522

Constant = -14.73595

Group mean: male = 3.18501

female = -4.96862

LOWER LEFT CANINE:

Measurement #1: Root width; canonical coefficient = 0.35785

Measurement #2: Crown length; canonical coefficient = 0.94795

Constant = -17.54882

Group mean: male = 3.89411

female = -5.54162

Table 3. Specimen number, sex, standard length, collection date, growth layer group (G.L.G.) counts of canine dentine, and estimated age of California sea lion (Zalophus californianus) specimens whose canine teeth are pictured in Figure 2.

Figure 2 code:	A	B	C	D	E	F	G	H
Specimen No.	MSL0193	DJS0011	LJH0043	MSL0245	LJH0011	MSL0281	MSL0214	LJH0022
Sex: ALL SPECIMENS ARE MALE								
Standard Length (cm)	~87	91.0	129.5	145.4	~165	186.0	216.0	231.5
Date Collected	81/11/15	83/1/19	82/5/20	82/6/23	82/1/7	82/12/15	82/5/3	82/5/5
G.L.G.'s	<1	<1	1	2	4	7	?	12
Estimated age	~5 mo.	~7 mo.	~11 mo.	2 yr.	4 yr.	7 yr.	?	12 yr.

Figure 2 code:	I	J	K	L	M	N	O
Specimen No.	CBH0021	MSL0200	LJH0038	MSL0255	MSL0189	MSL0257	MSL0234
Sex: ALL SPECIMENS ARE FEMALE							
Standard Length (cm)	80.0	98.8	116.3	132.0	~152	~165	179.5
Date Collected	83/10/22	82/1/27	82/5/19	82/7/13	81/11/15	82/7/23	82/6/10
G.L.G.'s	<1	<1	1	2	6-1/2	*10	*12
Estimated age	~4 mo.	~7 mo.	~11 mo.	2 yr.	6 yr.	10 yr.	12 yr.

DJS0011: Tagged 8 August 1982 as a pup at San Nicolas Island, California with Red Reise #492 (C.B. Heath, pers. commun.).
LJH0043: Tagged 10 September 1981 as a pup at San Clemente Island, California with White Roto #58 (C. Oliver, pers. commun.).
MSL0214: No canines were available for age determination.
* Pulp cavity occluded in canines of specimens MSL0257 and MSL0234.

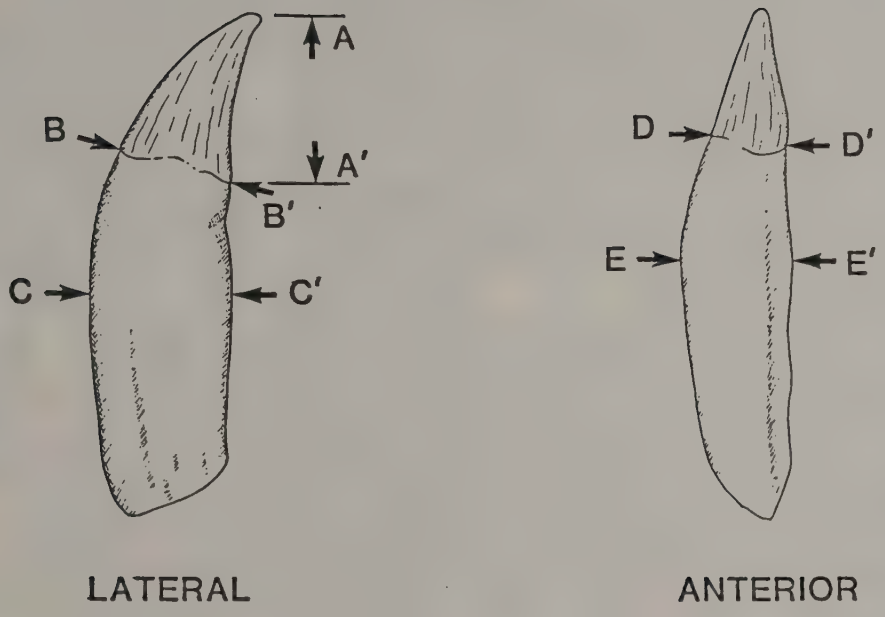

Figure 1. Measurements taken of California sea lion, Zalophus californianus, canine teeth (A-A' is crown length; B-B' is crown width; C-C' is root width; D-D' is crown thickness; and E-E' is root thickness).

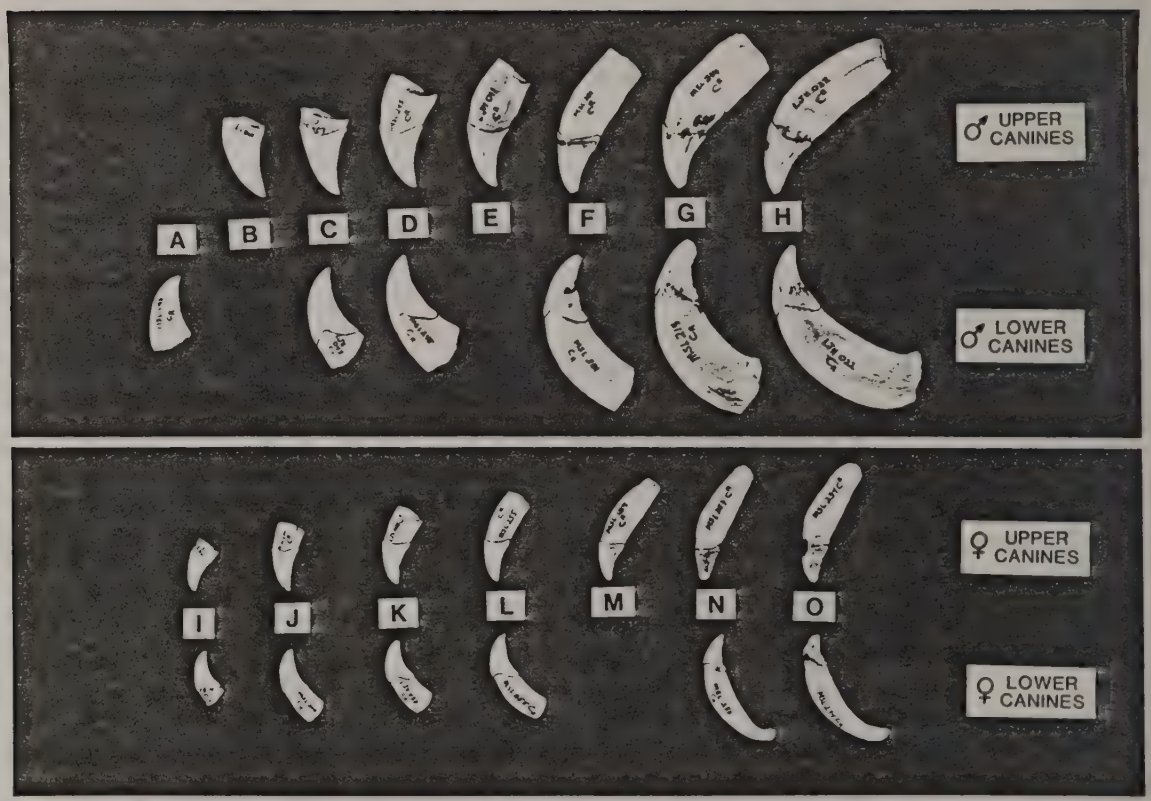

Figure 2. Ontogenetic series of upper and lower canine teeth from known-sex California sea lions (Zolophus californianus). The series for each sex are arranged from pup (left) to adult (right). Standard length and estimated age are given in Table 5 for each specimen (edge of the crown has been highlighted with pencil.)

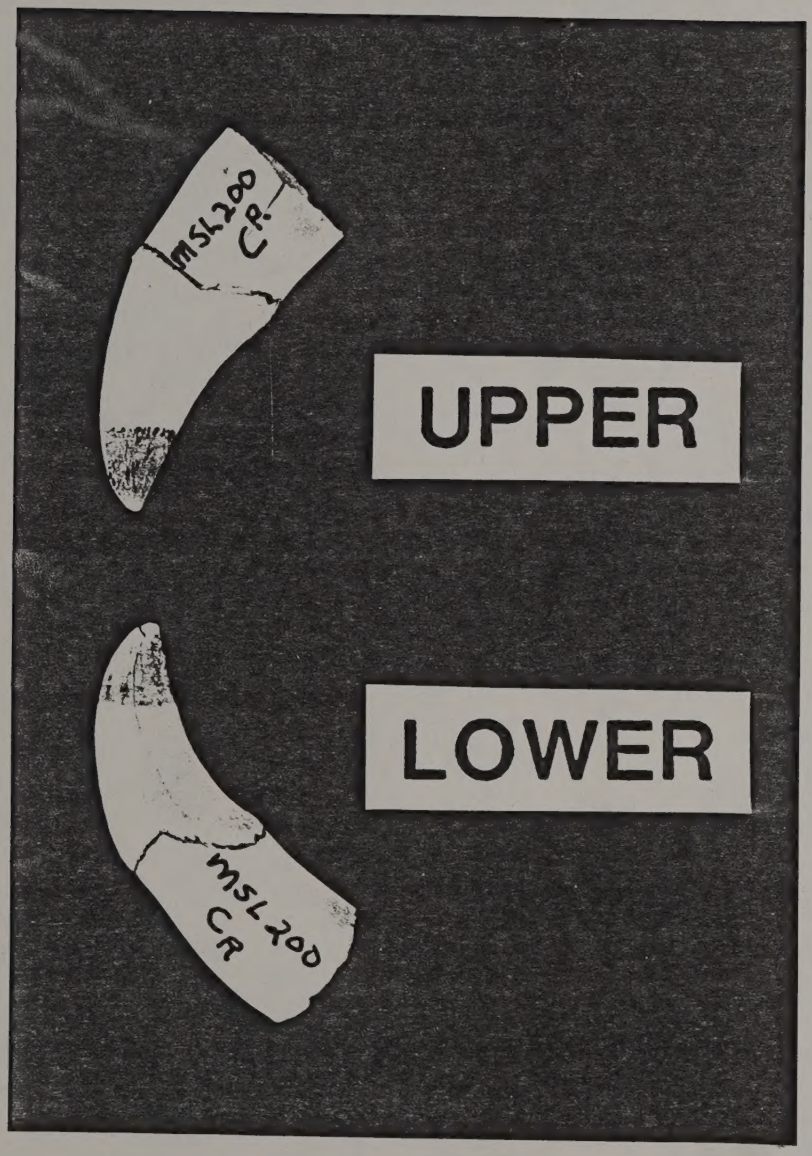

Figure 3. Canine teeth from an approximately 7 month old female California sea lion (Zalophus californianus) showing exposed region (discoloration) at the apex of a fully developed crown (edge of crown has been highlighted with pencil.)